

IN THE UNITED STATES PATENT  
AND TRADEMARK OFFICE

APPLICATION FOR  
UNITED STATES UTILITY PATENT

**SEMISUBMERSIBLE VESSELS & MOORING SYSTEMS**

INVENTORS

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# SEMISUBMERSIBLE VESSELS & MOORING SYSTEMS

## BACKGROUND OF THE INVENTION

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### Field Of The Invention

1. The present invention is directed to mooring systems for buoyant apparatuses and, in certain particular aspects, to semisubmersible vessels and systems for mooring them.

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### Description of Related Art

2. The prior art reveals a variety of semisubmersible vessels and systems for mooring them to a seabed or other surface.

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3. Semisubmersible vessels are used in the offshore industry for the purpose of drilling, production and marine operations. These semisubmersible vessels typically have two (or more) parallel spaced apart pontoons with columns upstanding from those pontoons to support a deck. In transit the vessel is deballasted so that it can float on the pontoons with the columns clear of the water. For activities which require a stable offshore platform, the vessel is ballasted down so that the pontoons are submerged, and only the columns pierce the water surface; thus giving the vessel a substantial buoyancy with a small waterplane area. A variety of cable, rope, chain and steel (e.g., steel wire) mooring systems have been employed for tethering the semisubmersible to the ocean floor to stabilize the vessel and to facilitate operations thereon. Thus a stable platform for offshore operations is provided that is more stable than an unmoored floating vessel.

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4. Economic development of offshore oil and gas fields in deeper and deeper waters and extreme environments has led to requirements for drilling, production and marine operations to be carried out in progressively more severe sea states. In certain

situations in relatively deeper waters chain and wire rope have been used in combination to provide the proper catenary and restoration forces into the mooring lines. The chain provide the weight needed for the restoring forces and the wire rope provided a desired catenary. Today to go into even deeper waters adding more chain or more wire rope adds weight to the system which must be borne by the deck of a vessel and the additional required equipment takes up space on the deck. Since deck space and vessel capacity are at a premium and deeper waters require additional tubulars and drilling fluid to be on the deck, operators have resorted to pre-laid systems in which the mooring line components, or part of them, are installed from additional separate vessels or boats rather than from the central vessel itself. This is time consuming and expensive.

5. Effective mooring systems are required that can stabilize a vessel or structure in very deep waters and despite severe conditions. A typical mooring lines can weigh over four million pounds and a typical vessel can have eight or more of such lines. It is well known in the art to employ anchor handling boats to move an anchor from a vessel to a desired drop point while line plays out from reel/winch apparatus on the vessel. To retrieve an anchor, an anchor handling boat uses a chaser line around the mooring line to lift the anchor and then the line attached to the anchor is retrieved by the reel-winch apparatus on the vessel. Service boats may also be used to pre-lay mooring lines to reduce the need for equipment on the vessel itself and to reduce space and load requirements on the vessel.

6. U.S. Patents 6,601,649; 4,735,267; 4,966,495; 2,987,892; 3,490,406; 3,982,401; 4,516,882; 5,791,819; 3,777,688; 1,228,756; 3,778,854; 4,010,619; 4,324,195; 5,117,914; 5,549,164; 5,855,178; 6,431,107; and U.S. Patent Application Publication of Nov. 28, 2002, No. 2002/0176747 to Hanna et al for U.S. Application Ser. No. 10/131,663 filed Apr. 24, 2002 and disclose typical prior art

systems and this application and all of these patents are incorporated fully herein for all purposes.

7. There are needs, recognized by the present inventors, for effective and efficient mooring systems for semisubmersible vessels. The present inventors have also recognized the needs for such systems which effectively utilize a self-contained synthetic rope system in dual or triple combination mooring lines yet which do not increase the weight and buoyancy requirements of a vessel. There is a need, recognized by the present inventors, to provide a mooring system that does not require that separate components of a multi-component mooring line be connected and disconnected from a separate boat or location rather than on a central vessel or structure.

#### SUMMARY OF THE PRESENT INVENTION

8. The present invention, in certain aspects, teaches self-contained mooring systems for vessels (and other structures) which use three line components that are connectible and disconnectible on the vessel itself. Systems according to the present invention can be retrofitted onto existing vessels. By mounting synthetic rope and synthetic rope handling equipment sub-sea on such vessels, systems according to the present invention do not significantly increase buoyancy requirements and do not significantly impact vessel deck space limitations. Also, with systems according to the present invention, connecting and disconnecting of the three components of a mooring line can be done at the location of the vessel itself; i.e., such systems do not require additional structures, boats or vessels to accomplish such handling and interconnection. Systems according to the present invention are useful for sea-going structures, for vessels, for semisubmersible vessels and vessels (semisubmersible or not) with such mooring systems. In one aspect, these mooring systems include one or more

triple combination mooring lines each with chain, steel line ("steel rope" or "wire rope") and rope components. In certain aspects synthetic rope is used for the rope component, e.g., but not limited to, rope that is neutrally buoyant (or nearly so) made of polyethylene terephthalate; polyethylene naphthalate; high modulus polyethylene; ARAMID <sup>TM</sup> material; aromatic polyamide; NYLON <sup>TM</sup> material; KEVLAR <sup>TM</sup> material; SPECTRA <sup>TM</sup> material; polypropylene; polyethylene; and polybutylene. Such ropes may be multi-strand; single or double braided; parallel twisted; jacketed; or non-jacketed. In one aspect steel wire is intertwined with synthetic rope and the reel-winch apparatus for this wire/rope composite line is submerged or is on a vessel's deck or platform above the water line.

9. In one aspect each of three components of a triple combination mooring line according to the present invention is provided from and retrieved by separate dedicated apparatus on a vessel or on a structure or platform. For example, a chain component is supplied by a known chain payout/retrieval apparatus; a steel wire component is supplied by a known steel wire reel/winch apparatus; and a rope component is supplied by a rope reel/winch apparatus.

10. In one particular aspect, rope reel/winch apparatus is mounted on a pontoon of a semisubmersible vessel and this reel/winch apparatus is submerged with the pontoon; or is mounted on either an above-water line part or a below-water-line part of a structure or platform. A below-water-line location for the rope reel/winch apparatus does not take up space on an above-the-waterline deck or platform of the semisubmersible vessel and the required buoyancy for the vessel is not increased. As desired, a tensioning and/or deployment apparatus (above or below the water line) is used in conjunction with the rope reel/winch apparatus. In certain aspects this device can be either a traction winch or a tractor winch. Power apparatus for the rope reel/winch apparatus

may be submerged or not. In certain aspects, the power mechanism is above the water line and associated and appropriate drive shaft(s), drive train(s), drive belt(s), and/or gearing or gear systems are interconnected with the rope reel/winch apparatus for powering it.

5 11. The present invention, in certain aspects, discloses a semisubmersible vessel having hull apparatus including a selectively submersible portion thereof, anchor apparatus, mooring line apparatus for connecting anchor apparatus to the hull apparatus, and the mooring line apparatus including at least one  
10 triple combination mooring line with three components including a first chain component, a second steel line component, and a third rope component; and, in one aspect, the rope component is synthetic rope that is located between the other two components. With any system according to the present invention, any known flotation  
15 device(s), apparatus, apparatuses, and/or systems, in any combination, may be used with any or all of a mooring line's components, either above or below water.

12. It is, therefore, an object of at least certain preferred embodiments of the present invention to provide:

20 13. New, useful, unique, efficient, non-obvious mooring systems, semisubmersible vessels, and methods of their use; and such systems and methods that are self-contained and employ one or more triple combination mooring lines;

25 14. Such systems and methods which provide a triple combination mooring line with interconnected chain, steel line (e.g. cable or wire), and rope which are connectible and disconnectible at a central location at a vessel or structure;

15. Such systems and methods which avoid the cost and expense of time-consuming pre-laid systems;

30 16. Such systems and methods which can employ known anchor handling vessels;

17. Such systems and methods which use a reel/winch apparatus for the rope component which, in use, is located on the vessel's

deck or below the water line;

18. Such systems and methods which employ current support vessels and/or which reduce the time and expense associated with mooring system installation;

5 19. Such systems and methods which do not adversely affect a vessel's operational capacity and which do not significantly increase a vessel's buoyancy requirements; and

20. In one aspect a vessel (submersible, semisubmersible or not) with an on-board rope reel-winch apparatus which, in one aspect, is submerged in use.

21. The present invention recognizes and addresses the previously-mentioned problems and long-felt needs and provides a solution to those problems and a satisfactory meeting of those needs in its various possible embodiments and equivalents thereof.

15 To one of skill in this art who has the benefits of this invention's realizations, teachings, disclosures, and suggestions, other purposes and advantages will be appreciated from the following description of preferred embodiments, given for the purpose of disclosure, when taken in conjunction with the accompanying drawings. The detail in these descriptions is not intended to thwart this patent's object to claim this invention no matter how others may later disguise it by variations in form or additions of further improvements.

#### 25 Description Of The Drawings

22. A more particular description of embodiments of the invention briefly summarized above may be had by references to the embodiments which are shown in the drawings which form a part of this specification. These drawings illustrate certain preferred embodiments and are not to be used to improperly limit the scope of the invention which may have other equally effective or equivalent embodiments.

23. Fig. 1 is a side schematic view of a prior art mooring system.

24. Fig. 2 is a side schematic view of a system according to the present invention.

5 25. Fig. 3 is a side schematic view of a system according to the present invention.

26. Fig. 4A is a top view of a pontoon of the system of Fig. 3. Fig. 4B is a top view of a vessel deck of the system of Fig. 3.

10 27. Figs. 5A and 5B are a schematic views of mooring lines emplaced according to the present invention.

DESCRIPTION OF EMBODIMENTS PREFERRED  
AT THE TIME OF FILING FOR THIS PATENT

15 28. Fig. 1 shows one prior art mooring system S in which mooring lines L with components including anchor chain N, synthetic rope R, and steel cable C are connected to anchors H. The cables C and anchor chains N are deployed from winch apparatus W mounted on a deck D of a semisubmersible vessel V with pontoons P (one shown). Typically the synthetic rope component is pre-laid by a  
20 separate vessel or system. A rig R is also mounted on the deck D.

29. Fig. 2 shows a semisubmersible vessel 10 according to the present invention which has two pontoons 12 (one shown) with columns 14 supporting a deck 16 on which are located a rig 18 and  
25 winch apparatus 20. As shown, the pontoons 12 are submerged below a waterline 19 and retrievable anchors 17 connected to anchor chains 50 rest on a seafloor 15.

30. Powered reel/winch apparatuses 30 with submersible power mechanisms 30a are mounted on the pontoons 12 from which ropes 32  
30 are deployed. i.e., they are self-contained on the vessel 10 itself rather than on another separate vessel or structure. It is within the scope of this invention to provide such synthetic rope apparatus on a submerged part of any vessel or structure and to use



such synthetic rope is combination with chain and/or wire rope, or both. Each rope 32 passes over a pulley 43 or 44 and then to a tensioning device 40 (which as shown is a dual-head driven winch apparatus with one or both heads driven and in another aspect is a rope traction winch) which is secured to the deck 16 above the water line 19. In other aspects according to the present invention the tensioning device is also below the waterline. From the tensioning device 40 the ropes 32 pass over rollers 34 and 24 and are connected to the anchor chains 50 between the anchor chains 50 and the steel wires 22 controlled by the winch apparatuses 20. The tensioning device 40, in one aspect has two heads 40a, 40b and the ropes 32 are movably wrapped around both heads several times so that a desired tension is achieved. Alternatively the reel/winch apparatuses 30 are powered by a power apparatus 30b which is on the deck 16 above the water line and appropriate power transmission structure or equipment 30c (e.g., but not limited to a drive shaft, a belt, or a gear system) conveys power to a power take-up device 30d (e.g., but not limited to a drive gear, a drive wheel, or a power take-off gear system) that powers the reel/winch apparatus 31. Although the semisubmersible vessel 10 is shown with a rig 18, it is within the scope of the present invention to provide any vessel or any semisubmersible vessel (with or without a rig and/or derrick or mast) with one or more triple combination mooring lines and associated reel/winch apparatus and/or tensioning apparatus according to the present invention. It is within the scope of the present invention to locate a synthetic rope reel/winch apparatus 30e (shown in dotted line in Fig. 2, like the apparatuses 30) with synthetic rope 32e above the water line on a vessel according to the present invention.

32. Figs. 3, 4A and 4B show a semisubmersible vessel 60 according to the present invention which has two pontoons 62 (one shown) interconnected by structures 62a and a deck 64 supported by supports 66. As shown the pontoons 62 of the semisubmersible

vessel 60 are submerged below a waterline 68. The semisubmersible vessel 60 has four anchors 71, 72, 73, 74 each with its own mooring line 81, 82 83, 84, respectively. A rope component of the lines 81 - 84 is supplied from submerged powered reel-winch apparatuses 91 - 94, respectively. Steel wire components are supplied, retrieved, and controlled by reel/winch apparatuses 101-104, respectively, mounted on the deck 64 and anchor chains are supplied, retrieved and controlled by anchor chain reel/winch apparatuses 105-108 mounted on the deck 64.

33. Tension, as desired, is applied to ropes 91a-94a from the reel-winch apparatuses 91-94 by a tension device 110 (like the tension device 40, Fig. 2 or any suitable known rope tension apparatus may be used). In one aspect the tension device has dual spaced-apart heads 110a which are driven and rotatable by a power source 110b (as may be the device of the vessel 10) around which the synthetic rope wraps multiple times so that sufficient tension is developed (with a sufficient number of wraps) so that the rope, its weight, and the weight of all that it supports is controllable with the rope reel/winch apparatuses. Each of the ropes 91a-94a traverse a roller 96 and a roller 97. Each anchor 71-74 has a corresponding anchor guide sheave or guide roller apparatus 71a-74a secured to the semisubmersible vessel 60.

34. Power mechanisms 91c - 94c for each of the reel-winch apparatuses 91 - 94, respectively, are also submerged (but may according to the present invention be on the deck 64 and appropriately interconnected to the reel/winch apparatuses) and may be any suitable known power apparatus which, in the submerged embodiment, may be any suitable known submergible power apparatus, including, but not limited to electric motors, hydraulic motors, or pneumatic motors.

Figs. 5A and 5B show triple combination mooring lines installed by methods according to the present invention with systems according to the present invention. Fig. 5A shows a system

120 according to the present invention for mooring a vessel 121 according to the present invention which is like the vessel 60, Fig. 3, or any vessel described herein according to the present invention. The vessel 121 with a rig of mast 135 has two spaced-apart submerged pontoons 122 (like the pontoons 62, Fig. 3) with a mooring line system 130 (shown schematically) like that disclosed for the vessel 60 or the vessel 10. An anchor 138 is connected to the vessel 121 with a triple combination mooring line 124. The triple combination mooring line 124 includes a wire rope component 125; a synthetic rope component 126 connected at one end with a connector 127 to the wire rope component 125; and a chain component 128 connected at one end with a connector 129 to an end of the synthetic rope component 126. The anchor 138 is embedded in the seafloor 136. the mooring line components 125, 126, and 128 are contained on and retrieved onto appropriate reel/winch apparatuses on the vessel 121, including mooring line system 130 for the synthetic rope component 126 and reel/winch apparatus 132 for the chain and wire rope components 125, 128 so that no synthetic rope needs to be pre-laid with other boats or vessels (although it is within the scope of the present invention to use systems according to the present invention in conjunction with other vessels and/or with part of any component pre-laid by such vessels).

Fig. 5B shows an alternative embodiment 120a of the system 120 (and like numerals indicate like parts). An amount of chain 134 is disposed between the wire rope component 125 and the synthetic rope component 126. As in other embodiments disclosed herein, the vessel 121 maybe, but is not limited to, a drilling/exploration vessel, a production vessel, or a platform, e.g., but not limited to, a production platform.

The present invention provides, therefore, in certain (but not necessarily all) embodiments, a mooring system for a structure positionable with part thereof under water, the mooring system

including rope, rope reel/winch apparatus for holding the rope and controlling the rope, the rope extendable from the rope reel/winch apparatus, the rope and rope reel-winch apparatus mounted on the part of the structure which is positionable underwater, the rope  
5 reel/winch apparatus operable when submerged. In such a mooring system the structure may be a rig, a platform, or a semisubmersible vessel.

The present invention provides, therefore, in certain (but not  
10 necessarily all) embodiments, a mooring system for a structure positionable with part thereof under water, the mooring system including synthetic rope, rope reel/winch apparatus for holding the synthetic rope and controlling the synthetic rope, the synthetic rope extendable from the rope reel/winch apparatus, the synthetic  
15 rope and rope reel-winch apparatus mounted on part of the structure. Such a mooring system may include a mooring line wherein the mooring line is a triple combination mooring line with three components including a first steel line component, the synthetic rope as a second component, and a third chain component; and  
20 wherein a first connector connects the first steel line component to the synthetic rope, a second connector connects the synthetic rope to the third chain component, and both the first connector and the second connector are handleable, connectible, and disconnectible at a location of the semisubmersible vessel.

The present invention provides, therefore, in certain (but not  
25 necessarily all) embodiments, a semisubmersible vessel with hull apparatus including a selectively submersible portion thereof, anchor apparatus, mooring line apparatus for connecting anchor  
30 apparatus to the hull apparatus with a mooring line, the mooring line apparatus including synthetic rope, and the mooring line apparatus having submersible rope reel-winch apparatus mounted on the selectively submersible portion of the hull apparatus. Such a

vessel may have one or some (in any possible combination) of the following: wherein the mooring line is a triple combination mooring line with three components including a first steel line component, a second synthetic rope component, and a third chain component; wherein a first connector connects the first steel line component to the second synthetic rope component, a second connector connects the second synthetic rope component to the third chain component, and both the first connector and the second connector are handleable, connectible, and disconnectible at a location of the semisubmersible vessel; a power mechanism on the semisubmersible vessel for powering the rope reel/winch apparatus; wherein the power mechanism is on the selectively submersible portion of the hull apparatus and is operable while submerged; wherein the anchor apparatus is a plurality of anchors and the mooring line apparatus is a plurality of mooring lines, each of the mooring lines connected to an anchor; wherein the hull apparatus is a plurality of spaced-apart selectively submersible pontoons; a deck on the hull apparatus; rig apparatus on the deck; deck chain reel/winch apparatus mounted on the deck for the first chain component and deck steel line reel/winch apparatus mounted on the deck for the second steel line component; tensioning apparatus secured to the semisubmersible vessel for selectively tensioning the rope; and/or wherein the tensioning apparatus is locatable above or below the water line when the selectively submersible portion of the hull is submerged.

The present invention provides, therefore, in certain (but not necessarily all) embodiments, a semisubmersible vessel with: hull apparatus including a selectively submersible portion thereof; anchor apparatus; mooring line apparatus for connecting the anchor apparatus to the hull apparatus with a mooring line, the mooring line apparatus including a triple combination mooring line with three components including a first chain component, a second steel line component, and a third synthetic rope component; the mooring

line apparatus having submersible rope reel-winch apparatus mounted on the selectively submersible portion of the hull apparatus associated with the third rope component for controlling, storing and retrieving the third rope component and from which the third rope component is extendable; wherein the submersible rope reel-winch apparatus includes a power mechanism operable while submerged; wherein the anchor apparatus is a plurality of anchors and the mooring line apparatus comprises a plurality of mooring lines, each of said mooring lines connected to an anchor; wherein the selectively submersible portion of the hull apparatus is a plurality of spaced-apart selectively submersible pontoons; the semisubmersible vessel having a deck on the hull apparatus; the semisubmersible vessel having deck chain reel/winch apparatus mounted on the deck for controlling the first chain component and deck steel line reel/winch apparatus mounted on the deck for controlling the second steel line component; and tensioning apparatus secured to the semisubmersible vessel above or below the water line for selectively tensioning the third rope component.

The present invention provides, therefore, in certain (but not necessarily all) embodiments, a semisubmersible vessel with: hull apparatus including a selectively submersible portion thereof; anchor apparatus; mooring line apparatus for connecting anchor apparatus to the hull apparatus with a mooring line, the mooring line apparatus including synthetic rope; and the mooring line apparatus including rope reel-winch apparatus mounted on the semisubmersible vessel.

The present invention provides, therefore, in certain (but not necessarily all) embodiments, methods for mooring a structure or vessel in water, at least part of the structure submerged in the water, the method including methods according to the present invention which use vessels, structures, and/or systems according

to the present invention. Such methods may include one or some (in any possible combination) of the following: wherein mooring line apparatus is a triple combination mooring line with three components including a first steel line component, a second synthetic rope component, and a third chain component, and wherein a first connector connects the first steel line component to the second synthetic rope component, a second connector connects the second synthetic rope component to the third chain component, and both the first connector and the second connector are handleable, connectible, and disconnectible at a location of the structure, the method including connecting the first steel line component to the second rope component at said location, and connecting the second synthetic rope component to the third chain component at said location; wherein the mooring line apparatus includes chain reel/winch apparatus mounted on the structure for controlling the third chain component and steel line reel/winch apparatus mounted on the structure for controlling the first steel line component, the method further including controlling the third chain component with the chain reel/winch apparatus and controlling the first steel line component with the steel line reel/winch apparatus; wherein the system includes anchor apparatus for anchoring the vessel or structure, the anchor apparatus having a plurality of anchors and the mooring line apparatus having a plurality of mooring lines, each of said mooring lines connected to an anchor.

35. In conclusion, therefore, it is seen that the present invention and the embodiments disclosed herein and those covered by the appended claims are well adapted to carry out the objectives and obtain the ends set forth. Certain changes can be made in the subject matter without departing from the spirit and the scope of this invention. It is realized that changes are possible within the scope of this invention and it is further intended that each element or step recited in any of the following claims is to be

understood as referring to all equivalent elements or steps. The following claims are intended to cover the invention as broadly as legally possible in whatever form it may be utilized. The invention claimed herein is new and novel in accordance with 35 U.S.C. § 102 and satisfies the conditions for patentability in § 102. The invention claimed herein is not obvious in accordance with 35 U.S.C. § 103 and satisfies the conditions for patentability in § 103. This specification and the claims that follow are in accordance with all of the requirements of 35 U.S.C. § 112. The inventors may rely on the Doctrine of Equivalents to determine and assess the scope of their invention and of the claims that follow as they may pertain to apparatus not materially departing from, but outside of, the literal scope of the invention as set forth in the following claims. Any patent or patent application referred to herein is incorporated fully herein for all purposes.

What is claimed is: